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# Presenting a New Method to Improve Seasonal Monitoring of Karun River Water Surface Temperature using Landsat-8 Satellite Images

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**ABSTRACT:** An accurate estimation of temperature for surface streams plays a key role in assessing quality parameters and additionally their quality classification. To obtain this goal, there are a variety of field methods and laboratory tools for measuring water surface temperature (WST). However, it is not possible to continuously measure temperature in these sources, so it is recommended to use remote sensing data as a key solution in which it is possible to continuously measure temperature. In the current study, four images of Landsat-8 satellite imagery were used at four different times (07/March/2019، 26/May/2019، 14/August/2019, and 02/November/2019) to estimate the water surface temperature of the Karun River. Thus, after applying the necessary preconceptions to the images, the first Normalized Differential Water Index (NDWI) was used to separate the water areas from other areas. Then, the river boundary was carefully selected and extracted from the Landsat-8 satellite thermal band. The water surface temperature was calculated using the corresponding programming algorithm in the IDL environment of the ENVI software. Finally, to make a comparison between the results of Remote Sensing and recorded WST values, the Root-Mean-Squared-Error (RMSE) parameters for March, May, August, and November months were 0.34, 0.4, 0.33, and 0.36 (°C), respectively, indicating the satisfying accuracy level. The results showed that the Remote Sensing data is an accurate instrument for estimating WSTs..

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## 1- Introduction

One of the important parameters in determining the water quality index is the water surface temperature (WST) [1]. Rivers are one of the most important sources of surface water transfer to various substrates, including drinking and agricultural purposes. Due to the variation in the geometric structure of rivers and long flow paths, measuring WST with special thermometers in the river is time-consuming and expensive. In addition, it is not possible to measure the water temperature across the river, and it will require experienced individuals and time, which is not economically viable. To solve these problems, remote sensing (RS) is suggested as a key solution.

In general, RS sensors are divided into active (radar) and inactive (optical). Passive sensors use the sun as an energy source. In contrast, there are active sensors that carry the energy source with them. Therefore, RS and the systems used can provide very useful information in various applications such as WST retrieval. Numerous studies have been performed to calculate the WST using RS data [2, 3].

Many studies in the field of calculating the WST used satellite images with very low resolution, which examined the WST in sea and lake on a large scale [4-6]. However, the study of WST in rivers and narrow water areas received less attention. The reason for this is the inability of satellite images with a low spatial resolution to distinguish the exact boundary of the river. Also, the methods used to accurately select the river have not been geometrically robust.

Therefore, the present study aims to calculate the water temperature of the Karun River by separating the boundary of the Karun River water area using satellite images with medium spatial resolution, which has not been studied in any study.

## 2- Case Study and Data

The study area is part of the Karun River in Khuzestan Province, which is located in southwestern Iran.

In the current study, four images of Landsat-8 satellite imagery were used at four different times (07/March/2019، 26/May/2019، 14/August/2019, and 02/November/2019) to estimate the WST of the Karun River. The satellite data covers the entire globe and is available for free from the USGS website. To evaluate the extracted temperatures from the RS data, the temperature of ten specific points in proportion to the imaging time of the Karun River was used.

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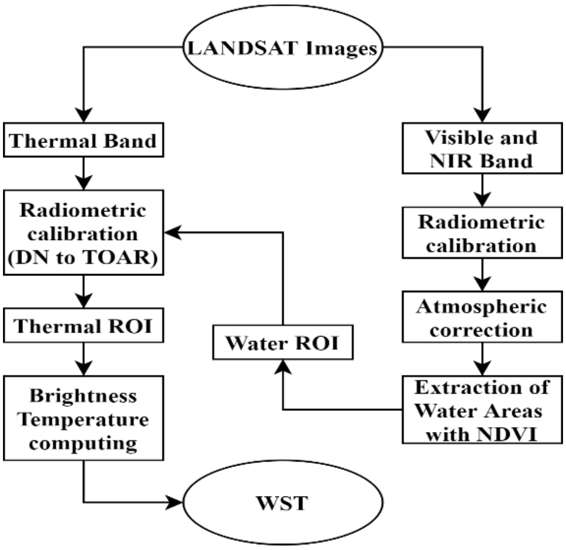


**Fig. 1. Flowchart for calculating the water surface temperature of Karun River.**

## 3- Methodology

### 3- 1- Pre- Processing and WST Retrieval

The process of making the necessary pre-processing on the Landsat-8 images and how to calculate the WST of the Karun River is shown in the flowchart of Fig. 1.

According to Fig. 1, in the first stage, Preprocessing related to visible, near-infrared, and thermal bands including radiometric and atmospheric corrections were performed, then the spatial resolution of thermal bands was improved from 100 meters to 30 meters. In the next step, the normalized differences water index (NDWI) was generated using Eq. (1) and was used to isolate and accurately cut the River boundary from other features.

$$NDWI = \frac{G - NIR}{G + NIR} \tag{1}$$

In Eq. (1), NDWI is the normalized differential water index, NIR is the amount of near-infrared band reflectance and G is the green band reflectance of Landsat-8 satellite imagery. Using this index, water values can be extracted in different intervals. The value of the NDWI varies between +1 and -1, in which values above 0.2 to +1 are classified as water. Finally, by calculating the values of brightness temperature (BT) from Eq. (2), WST was calculated and compared with the obtained data from field observations.

$$T = \frac{k_2}{\ln\left(\frac{k_1}{L_\lambda} + 1\right)} \tag{2}$$

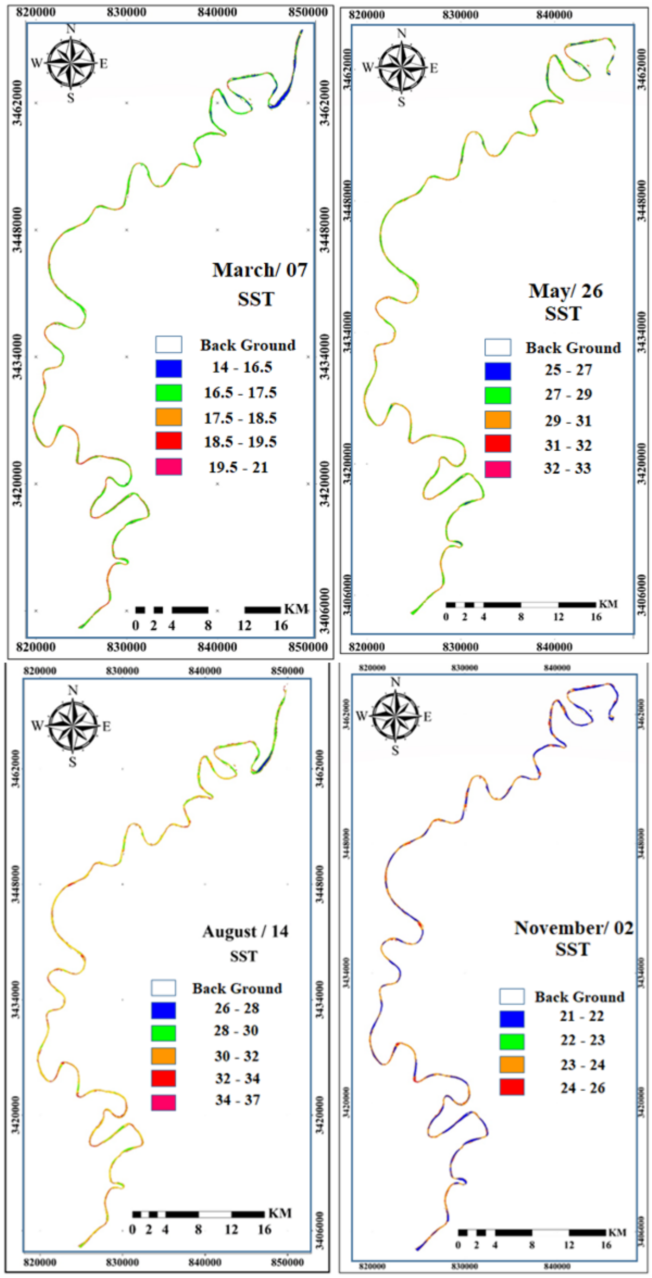


**Fig. 2. WST of Karun River at different times.**

In Eq. (2), T is the BT in Kelvin; K1 and K2 are the conversion coefficients of the 11th thermal band of the Landsat-8 satellite, which are equal to 480.8833 and 1201.1442, respectively.

## 4- Results and Discussion

The results of the calculated WST for all times are shown in Fig. 2. Based on the results of the temperature calculated using the RS data, the temperature for the study area varies between 14 and 37 (°C), which is hot during the summer and cold in the winter. Finally, to make a comparison between the results of remote sensing and recorded WST values, the root mean squared error (RMSE) parameters for March, May, August, and November months were 0.34, 0.4, 0.33, and 0.36 (°C), indicating the satisfying accuracy level.

## 5- Conclusion

In the present study, the proposed method can be used in all rivers with a width of more than 30 meters and at any depth with high accuracy. The values of statistical indicators for the studied months showed that RS models have an acceptable performance. The application of this method, in addition to WST estimation, is in areas related to water sciences, such as accurate water body extraction, flood mapping, and accurate extraction of the shoreline of lakes and rivers. Based on the findings of current research, and through the study area, it was shown that RS systems and data as suitable tools to estimate the amount of WST continuously in less time and at higher speeds.

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